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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 118.
B. T. GALLOWAY, *Chief of Bureau.*

PERUVIAN ALFALFA:

A NEW LONG-SEASON VARIETY FOR THE SOUTHWEST.

BY

CHARLES J. BRAND,

PHYSIOLOGIST, IN CHARGE OF CLOVER AND ALFALFA INVESTIGATIONS, PLANT LIFE HISTORY INVESTIGATIONS.

ISSUED DECEMBER 23, 1907.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1907.

DEC 24 1907

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[Continued on page 3 of cover.]

A SINGLE PLANT OF PERUVIAN ALFALFA, ONE YEAR OLD.

(Three feet high to arrow.)

U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 118.
B. T. GALLOWAY, *Chief of Bureau.*

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GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., September 26, 1907.

Sir: I have the honor to transmit herewith, and to recommend that it be published as Bulletin No. 118 of the series of this Bureau, the accompanying manuscript, entitled "Peruvian Alfalfa: A New Long-Season Variety for the Southwest." This paper was prepared by Mr. Charles J. Brand, Physiologist, in charge of Clover and Alfalfa Investigations, Plant Life History Investigations, and has been submitted by Mr. Walter T. Swingle, Physiologist in Charge, with a view to publication.

The parent seed on which practically the whole alfalfa industry in the United States is based was originally imported from Chile, but comparatively few experiments have been conducted with alfalfa of South American origin. In the present paper Mr. Brand describes an alfalfa from Peru so different from the one commonly grown as to constitute, in his opinion, a distinct botanical variety. This new form is of great promise from a practical point of view, because it not only has a longer growing season, but recovers more quickly after cutting and grows to a larger size, hence yielding decidedly more than ordinary alfalfa.

Study of its life history requirements shows that it can be grown to greatest advantage only under irrigation and in the Southwest, where the climate is mild enough to permit its growth all winter.

Life history studies reveal and explain the weak points of new varieties of crop plants as well as their advantages. Mere variety tests do not usually give any explanation of the causes of success or failure and do not remove the danger of serious loss through attempting the culture of a new variety under conditions to which it is utterly unsuited.

Peruvian alfalfa is, for example, less harmed by frost than ordinary varieties and in the Southwest continues to grow throughout the winter. From this it might be supposed to be hardy, but on the contrary it proves in the Great Plains region to be the most tender alfalfa

known. Such results are mere paradoxes until explained by an understanding of its life history requirements and limiting conditions, which at the same time renders it possible to point out with confidence the only regions where Peruvian alfalfa promises to be superior to the sorts now commonly grown.

The experiments on which this bulletin is a partial report were inaugurated in 1904 and have been carried on under a cooperative arrangement between Plant Life History Investigations, the Seed Laboratory, and the Office of Seed and Plant Introduction.

The seed used in this work was sent to the Department of Agriculture by Mr. Adolfo Eastman y Cox, of Chile.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

	Page.
Introduction	7
Life history study of alfalfa inaugurated	7
Continuous growth of the Peruvian variety throughout the winter in the Colorado River valley	8
Zero point of growth as explaining hardiness of alfalfa	8
Effect of low zero point under unfavorable conditions	9
Practical significance of low zero point under favorable conditions	9
Probable location of the zero point of Peruvian alfalfa	9
Difficulty of locating the zero point	12
Comparison between amount of growth of Peruvian and several other alfalfas	14
Comparison of Arabian with Peruvian alfalfa	16
Recent botanical history of cultivated alfalfa	18
Wild forms of Medicago sativa	19
Differences which distinguish Peruvian alfalfa	20
Peruvian alfalfa constitutes a new botanical variety of Medicago sativa	23
Peruvian alfalfa seeds abundantly	24
Source of Peruvian seed	25
Alfalfa propagated by cuttings	26
The Guaranda alfalfa of Ecuador	27
Advantages and disadvantages of Peruvian alfalfa	28
Summary	29
Description of plates	32
Index	33

ILLUSTRATIONS.

PLATES.

Page.

PLATE I. A single plant of Peruvian alfalfa, one year old ..... Frontispiece.

II. Fig. 1.—A plat of Peruvian alfalfa on the United States Reclamation Service tract, Yuma, Ariz. Fig. 2.—A plat of Kebilli Oasis alfalfa growing on a plat contiguous to that of the Peruvian variety shown in fig. 1 32

III. A specimen of Peruvian alfalfa, showing flowers and almost mature head 32

TEXT FIGURES.

FIG. 1. Diagram showing the monthly mean temperatures for 1906 at Yuma, Ariz., and their utilization by Peruvian and by common alfalfas 10

2. Curves representing the average maximum, mean, and minimum temperatures for 1906 at Yuma, Ariz 11

3. Comparative growth of various alfalfas: 1, Peruvian; 2, Arabian; 3, Turkestan; 4, Arizona 15

4. Floral parts of common alfalfa 18

5. Floral parts of Peruvian alfalfa 18

6. Cross section of midrib of terminal leaflet of Peruvian alfalfa, showing broad band of colorless water-storage tissue 21

7. Cross section of midrib of terminal leaflet of ordinary alfalfa, showing narrow band of colorless water-storage tissue 21

8. Three, four, five, and six leafed forms of Peruvian alfalfa 22

9. Flower of common alfalfa, showing calyx teeth as short as calyx tube 23

10. Flower of Peruvian alfalfa, showing calyx teeth longer than calyx tube 23

11. Small mature head of Peruvian alfalfa, showing expanded spiral pods 24

12. Local thickenings of the walls of the epidermal cells of Peruvian alfalfa leaves 24

NOTE.—The specimen of common alfalfa used in making figs. 4, 7, and 9 was grown in Arizona from Utah seed. Figs. 6, 7, and 12 are made from drawings by Dr. Theo. Holm from specimens.

B. P. I.—315.

PERUVIAN ALFALFA: A NEW LONG-SEASON VARIETY FOR THE SOUTHWEST.

INTRODUCTION.

Alfalfa continues to hold the attention of practical farmers throughout the United States, and a very large area of land is annually devoted to this plant, which is indeed the staple crop of the irrigated lands west of the one hundredth meridian. For this reason, it seems desirable to publish promptly all observations of scientific or economic importance on the life history of alfalfa and its varieties.

LIFE HISTORY STUDY OF ALFALFA INAUGURATED.

The very great value of the alfalfa crop to a large part of our country, especially to those sections where irrigation is practiced, has resulted in the importation of seed from sources very widely separated geographically and having vastly different soil, climatic, and other conditions. The effort to find strains suitable for regions where the successful culture of this crop has not yet been established has also contributed to this result.

In 1904 a life history study of alfalfa was instituted in the Bureau of Plant Industry, which, although far from being completed, has already yielded some results of a sufficiently important and suggestive nature to make it advisable that they be placed at the disposal of both the farmer and the experimenter.

In the course of the investigations on which this paper is a partial report, about thirty regional strains of alfalfa have been kept under observation for three years. Among these there is one from Peru whose unusually rapid growth, quick recovery after cutting, and continued growth through the winter in favorable climates result in the production of one or two more cuttings of hay each year than are yielded by the alfalfa commonly cultivated. The present bulletin is a summary of what is known about this remarkable variety.

CONTINUOUS GROWTH OF THE PERUVIAN VARIETY THROUGHOUT THE WINTER IN THE COLORADO RIVER VALLEY.

One of the most striking facts and perhaps the most important one noted in reference to the Peruvian variety is its complete lack of hardiness in all northern localities. From Groom, in the Panhandle of Texas (lat. 35° 12′ N.), to Indian Head, Saskatchewan (lat. 50° 28′ N.), on an average at least 99 per cent of the plants of this variety have been winterkilled during the past three years. Other sorts of alfalfa used in these experiments also suffered in varying degree, but none so severely as the Peruvian variety. Some few of them, such as the hardy Grimm alfalfa from Minnesota, and that grown from seed produced in the Milk River valley in northern Montana, showed no injury to the stand from winterkilling during the same period. On the other hand, curiously enough, at Yuma and at Phoenix, Ariz., frosts sufficiently severe to prevent the growth of all other kinds except the Arabian had no effect on the Peruvian variety, which continued to grow throughout the winter and was on February 28, 1907, ready for its first cutting, having by that date attained a height of nearly 2 feet.

Alfalfa grown in Arizona from Arizona, Provence, Turkestan, and northern Montana seed had all ceased growing in the autumn practically with the first frosts, while the Peruvian, which had winterkilled so universally at northern stations, grew throughout the year. Thus we have the paradox of the hardier strains having their growth almost wholly interrupted by the mild Arizona winter, while a variety known to be sensitive to cold has grown continuously under these same conditions.

ZERO POINT OF GROWTH AS EXPLAINING HARDINESS OF ALFALFA.[a]

A consideration of the physiological causes underlying the condition described has led to the conclusion that the explanation for it must be sought in the difference in the location of the zero point[b] of growth in Peruvian and in ordinary alfalfa.

In the form under discussion the zero point of growth is unusually low; that is, its growth will continue despite unusually low temperatures. Practically all other sorts of alfalfa, and indeed almost all crop plants, stop growing before the minimum for this variety is reached. The direct consequence of this low zero point under the climatic conditions that prevail in the Colorado River valley near

[a] The explanation of hardiness here published for the first time was suggested to the writer by Mr. Walter T. Swingle in the course of a discussion of the life history requirements of Peruvian alfalfa.

[b] The zero point of growth of any variety may be defined as the minimum temperature below which growth ceases.

Yuma and in the Salton Basin is continued growth of the Peruvian alfalfa throughout the winter season, although the cold is sufficient to prevent activity in practically all other varieties.

EFFECT OF LOW ZERO POINT UNDER UNFAVORABLE CONDITIONS.

In colder regions the low zero point results in the plant being unaffected by the cool weather of the autumn, which in the case of other varieties of alfalfa first merely retards growth and finally arrests it altogether.

Because of its low zero point, Peruvian alfalfa does not cease growing in the autumn, and as a consequence it is caught with tender growth and killed by the first severe freeze, while other alfalfas, having gone into the resting stage, are not harmed.

PRACTICAL SIGNIFICANCE OF LOW ZERO POINT UNDER FAVORABLE CONDITIONS.

The most obvious advantage to a plant of a low zero point under favorable conditions is that growth continues long after it has ceased in plants having a high zero point. In the Salton Basin, in the Colorado and Salt River valleys, and in other sections which have mild winter weather, the Peruvian variety makes a very considerable winter growth, while the other alfalfas make practically none. (See fig. 3.) This winter growth furnishes valuable pasturage for cattle and hogs and food for poultry, or if allowed to remain on the field results in the production of an extra crop of hay, thus increasing the yield to the acre from 15 to 20 per cent each year.

Inasmuch as green alfalfa is the food preferred throughout the year for ostriches, this strain and, in a less degree, the Arabian have a decided advantage over all others for ostrich farming, which is becoming an important industry in the very region to which this alfalfa is best adapted.

There are high valleys in New Mexico, Arizona, and Colorado, where the winters are mild, to which Peruvian alfalfa may prove to be adapted. It is also possible that this form may be as hardy as any other in sections where the approach of cold weather is gradual enough to force it to suspend growth before winter arrives.

It is evident from the foregoing that the possession of a low zero point is a great advantage under favorable conditions and an equally great disadvantage under unfavorable conditions. Hence this factor must be given consideration before it can be determined into what regions alfalfa may be introduced with profit.

PROBABLE LOCATION OF THE ZERO POINT OF PERUVIAN ALFALFA.

Inasmuch as complete weather records are available for Yuma, a careful study of these has been made in the hope of determining, approximately, the zero point of Peruvian alfalfa. The experimental

plats are located but a few hundred feet distant from the Weather Bureau station. An examination of the records shows that the mean temperature for the months from October, 1906, to February, 1907, inclusive, was 61.8° F. Considerable growth was made throughout this period. The lowest monthly mean was 53.8° F. for January. During this month less growth was made, but it was not entirely interrupted. From this it would appear that under the given conditions the zero point is located somewhere below 53° F. However, according to the records for the Arizona Experiment Station, the mean for the same months at the station farm near Phoenix was 57.7° F., the lowest monthly mean being 50.7° F. for January, 1907. Here also growth was made during the winter months, including January, with a mean a little more than 50° F. Hence it is evident that the zero point of the Peruvian variety is below 50° F., probably

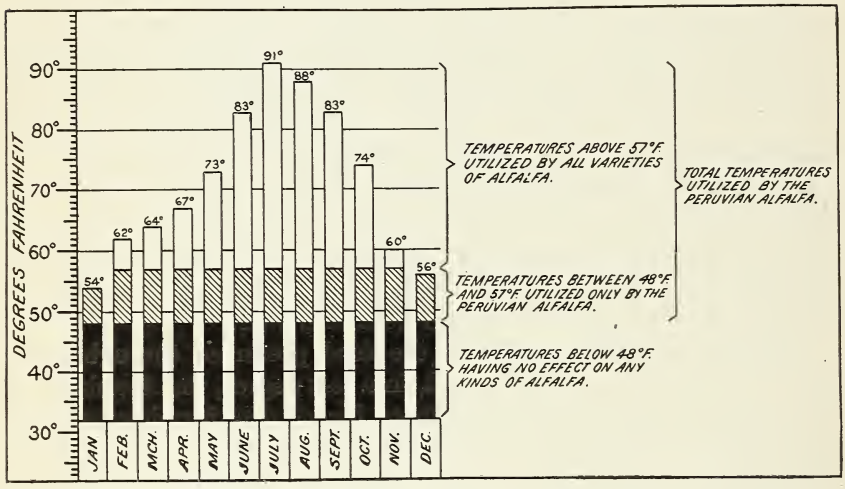

FIG. 1.—Diagram showing the monthly mean temperatures for 1906 at Yuma, Ariz., and their utilization by Peruvian and by common alfalfas.

about 48° F., while that of the common form lies between 53° F. and 61° F., perhaps at about 57° F. In any case it is hard to locate the zero point accurately, especially for ordinary alfalfa, on account of the disturbing factor introduced by the direct action of frost in killing the leaves.

The accompanying diagram (fig. 1) shows graphically the advantage which the low zero point gives the Peruvian over the ordinary kinds. The mean temperature for each month during 1906 is represented by a column. The solid base extending from the freezing point to 48° F., the approximate zero point of the Peruvian variety, represents the temperatures which have no effect on any kinds of alfalfa; the cross-hatched portion between 48° F. and 57° F., the estimated zero point of ordinary alfalfa, shows the temperatures

which can be used by this variety only, while the part of each column above 57° F., and extending up to the mean for each month, represents the temperature utilized by other alfalfas as well as the Peruvian. All temperatures above the solid bases of the monthly columns are utilized by the Peruvian, while only those above the cross-hatched portion are used by the ordinary strains. The additional heat units available on account of the low zero point explain, in a measure, the more rapid growth of this new form.

The chart shows that in December and January, when considerable growth could be made by the Peruvian alfalfa, none whatever was possible by any other variety, because the mean for both of these

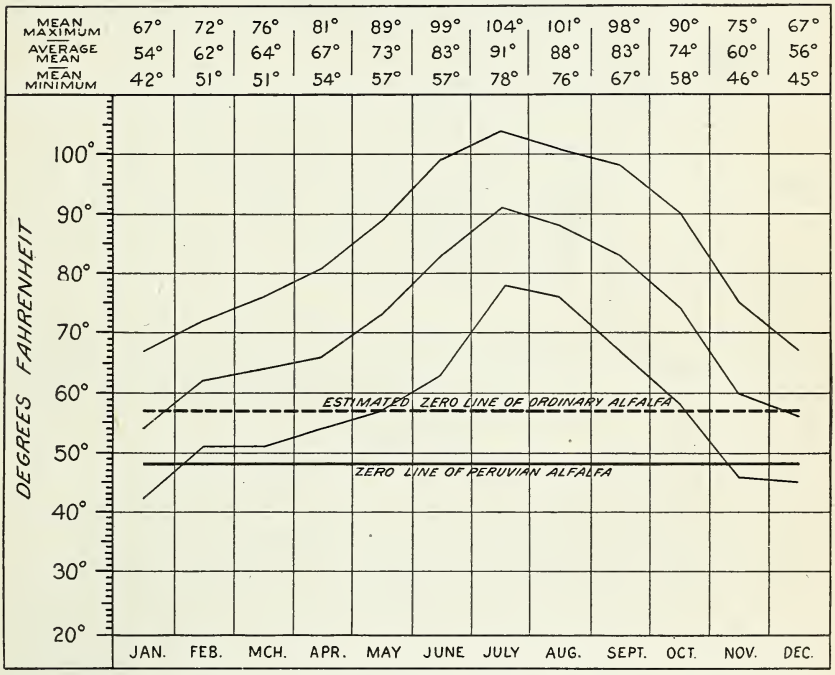
MEAN MAXIMUM 67° 72° 76° 81° 89° 99° 104° 101° 98° 90° 75° 67°
AVERAGE MEAN 54° 62° 64° 67° 73° 83° 91° 88° 83° 74° 60° 56°
MEAN MINIMUM 42° 51° 51° 54° 57° 57° 78° 76° 67° 58° 46° 45°
DEGREES FAHRENHEIT
100°
90°
80°
70°
60°
50°
40°
30°
20°
ESTIMATED ZERO LINE OF ORDINARY ALFALFA
ZERO LINE OF PERUVIAN ALFALFA
JAN. FEB. MCH. APR. MAY JUNE JULY AUG. SEPT. OCT. NOV. DEC.

FIG. 2.—Curves representing the average maximum (upper curve), mean (middle curve), and minimum (lowest curve) temperatures for 1906 at Yuma, Ariz.

months was below the zero point of ordinary alfalfa. There was one exception to this, namely, the Arabian, which will be briefly discussed in a later paragraph. The zero point of this strain lies between that of the Peruvian and that of the ordinary alfalfa.

The diagram shows temperatures that might be used by ordinary alfalfa in both February and November. However, when frost occurs during these months, ordinary alfalfa is retarded and prevented from making full utilization of the available heat. Furthermore, it will be seen by reference to figure 2 that the curve representing the average of the minimum temperatures lies considerably

below the estimated zero point of common alfalfa during both of these months.

For convenience of expression mean temperatures above the zero point may be called positive and those lying below negative. The former, when long enough continued, stimulate growth, while the latter would seem at first sight to be merely useless. However, further observation goes to show that negative temperatures are actually harmful, as they prevent the complete utilization of available positive temperatures. Before growth can proceed after cold nights a warm sun for several hours is required to take off the chill.[a]

Only during January and December did the Peruvian alfalfa suffer from nocturnal chilling, and then but slightly, since only a small proportion of the temperatures for these months fell decidedly below its zero point for growth.

A further examination of figure 2 shows that the minimum curve for November, December, January, February, March, and April extends below the zero line of common alfalfa, while only during December and January does any considerable portion of the curve extend below the zero line of the Peruvian variety. This means that common alfalfa suffered retardation during six months of the year, while the Peruvian form was affected during but two, and then but slightly.

Coincident with the low zero point of the new form a low optimum might be expected, but this has not been found to be the case. Indeed, its optimum appears to be fully as high as that of any other alfalfa. An explanation of this fact is given later.

DIFFICULTY OF LOCATING THE ZERO POINT.

On the difficulty of locating the zero point, De Candolle,[b] who made extensive investigations on the heat requirements of plants, says:

> The most difficult points to fix are the minima. One is rarely in possession of such direct observations as to permit establishing them. One is then compelled to seek them by groping, through comparison between the different extreme localities where the species extends. I often succeeded in doing this in a more or less satisfactory manner. My investigations as a whole show one thing I was not thinking of while busy with the details, namely, that the minima generally rise in proportion as more southerly species are concerned.

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[a] Mr. Walter T. Swingle has called attention to this phenomenon in Bulletin 53 of the Bureau of Plant Industry, "The Date Palm and its Utilization in the Southwestern States." In the course of some studies on the date palm during October and November, 1906, at Tempe, Ariz., and Mecca, Cal., the present writer observed that when the night temperatures fell decidedly below 64.4° F., the conventional zero point for the date palm, no advance whatever was made in ripening during the succeeding day, although the maxima were often fully as high as on days when normal progress was made. In other words, warm nights were just as essential for the proper ripening of the fruit as were hot days.

[b] De Candolle, Alphonse. Géographie botanique raisonnée, Paris and Geneva, 1855, vol. 1, p. 395.

The present investigations do not bear out De Candolle's last statement, as in the Peruvian alfalfa we have a southerly form which has a decidedly lower minimum (i. e., zero point) than those from more northerly regions. This may be accounted for by the fact that alfalfa is an introduced plant in South America, and the variety under discussion has adjusted itself to the climatic conditions of high plateaus in an equatorial latitude.

Alfalfa was no doubt brought into Peru at the time of the Spanish conquest, more than three hundred years ago. During the long period that has since elapsed, a rigid though unconscious selection has probably gone on. Only those plants having a low zero point were able to produce seed, the sum of heat being insufficient to ripen the seed of forms having a high zero point.

The parent alfalfa which the Spaniards brought with them to Peru probably came originally from the hot deserts of the Old World. Millenia of growth in desert climates necessitating adaptation to withstand long, hot summers preceded the relatively short period of rigid selection already mentioned, tending to adapt the plant for growth at low temperatures. The high optimum temperature of growth of Peruvian alfalfa was probably developed during its stay in the Old World deserts, and it still persists after a few centuries of culture at high altitudes in the Andes. If grown long enough under conditions that do not call into use the ability to grow at high temperatures, doubtless the power to thrive in very hot weather would be lost, just as has been observed in the case of blind cave fishes whose sight organs became atrophied through disuse.

The possession of a low zero point by Arabian alfalfa [a] suggests that possibly the parent seed of Peruvian alfalfa likewise originated in a region where, in addition to hot summers, there were mild winters, during which growth was possible in plants having a low zero point. In this case the unusually low zero point of Peruvian alfalfa represents only the further development of a character already present.

Weather records for Peru, and indeed all South American countries, are unsatisfactory, but Hann [b] gives a rather complete summary for both Lima, Peru, and Quito, Ecuador. The mean annual temperature of Quito is 56.3° F.; the warmest months, December and January, have a mean of 56.66° F.; the mean of the coldest month is 56.32° F., the difference in mean between the coldest and the warmest month being only 0.34 of 1 degree. Any crop plant to succeed at all under such climatic conditions must have a zero point at least as low

[a] See the discussion on pages 16 to 18, under the heading "Comparison of Arabian with Peruvian alfalfa."

[b] Hann, Julius. Handbuch der Klimatologie, 2d ed., Stuttgart, 1897, vol. 2, pp. 323–349.

as the mean monthly temperature of the warmest month—in this case 56.66°.

If it were not as low as this, there would not be sufficient heat to stimulate the plants into growth. On the other hand, a zero point considerably lower than this would be a distinct advantage, as the optimum temperature of growth lies considerably above the zero point.

The mean yearly temperature at Lima is 66.2° F. The mean of the warmest month, February, is 73.76° F.; of the coldest month, July, 58° F. The difference between the annual mean maximum and minimum is 15.76° F. This difference is much greater than that for Quito. However, the only place in the United States having so small a difference as this is San Diego, in southern California. Following is a table giving the mean temperatures for the year and for the warmest and coldest months at four places each in South America and North America. Temperatures are given in degrees Fahrenheit and altitudes in feet.

TABLE I.—*Comparison of mean temperatures of some South American and North American localities.*

Place.	Latitude.	Longitude.	Altitude.	Mean temperature in degrees Fahrenheit.					
				Annual.	Warmest month.	Month.	Coldest month.	Month.	Difference.
	° ′	° ′	*Feet.*						
Quito	0 14 S.	78 32 W.	9,350	56.3	56.66	Dec., Jan.	56.32	July	0.34
Lima	12 4 S.	79 21 W.	524	66.2	73.76	Feb.	58.0	do	15.76
Guayaquil	2 10 S.	79 56 W.	(a)	76.6	83.3	Jan.	77.9	do	5.4
La Paz	16 30 S.	68 10 W.	11,972	50.0	54.5	Nov.	45.14	June	8.36
San Diego	32 43 N.	117 10 W.	40	61.0	70.0	Aug.	54.0	Jan.	16.0
Yuma	32 45 N.	114 36 W.	137	72.0	92.0	July	54.0	do	38.0
Washington	38 54 N.	77 3 W.	75	55.0	79.0	do	33.0	do	46.0
St. Paul	44 58 N.	93 3 W.	758	45.0	74.0	do	12.0	do	62.0

[a] Sea level.

A study of these data would indicate that alfalfas with a low zero point would do better than any others in such an even, cool climate as San Diego, and this will no doubt prove true, but the fact that the Peruvian variety does so well at Yuma demonstrates further that its maximum temperature (above which growth ceases) is considerably higher than the mean for the hottest month (94° F. in July) at Yuma.

COMPARISON BETWEEN AMOUNT OF GROWTH OF PERUVIAN AND SEVERAL OTHER ALFALFAS.

In order to illustrate more effectively the great diversity in the amount of growth made during the winter by different regional strains average specimens were selected from each of the plats on

the reclamation tract at Yuma, Ariz. Figure 3 shows (at one-fourth natural size) specimens grown from Peruvian, Arabian, Turkestan (Samarkand), and native Arizona seed.

These specimens in each case were selected to represent the average condition of the plats and therefore may be considered directly comparable. The plants from which the figures were made were collected about the middle of November, 1906. At that time the average height of the Peruvian variety was 24 inches and of the Arabian 19 inches, while that of the Turkestan and native Arizona alfalfas was 12 and 10 inches, respectively. Furthermore, practically all growth had ceased in the last two named. From this it is apparent that the Peruvian alfalfa was 5 inches taller than its nearest competitor, the Arabian, 12 inches taller than the Turkestan strain, and 14 inches taller than the plants produced from home-grown Arizona seed.

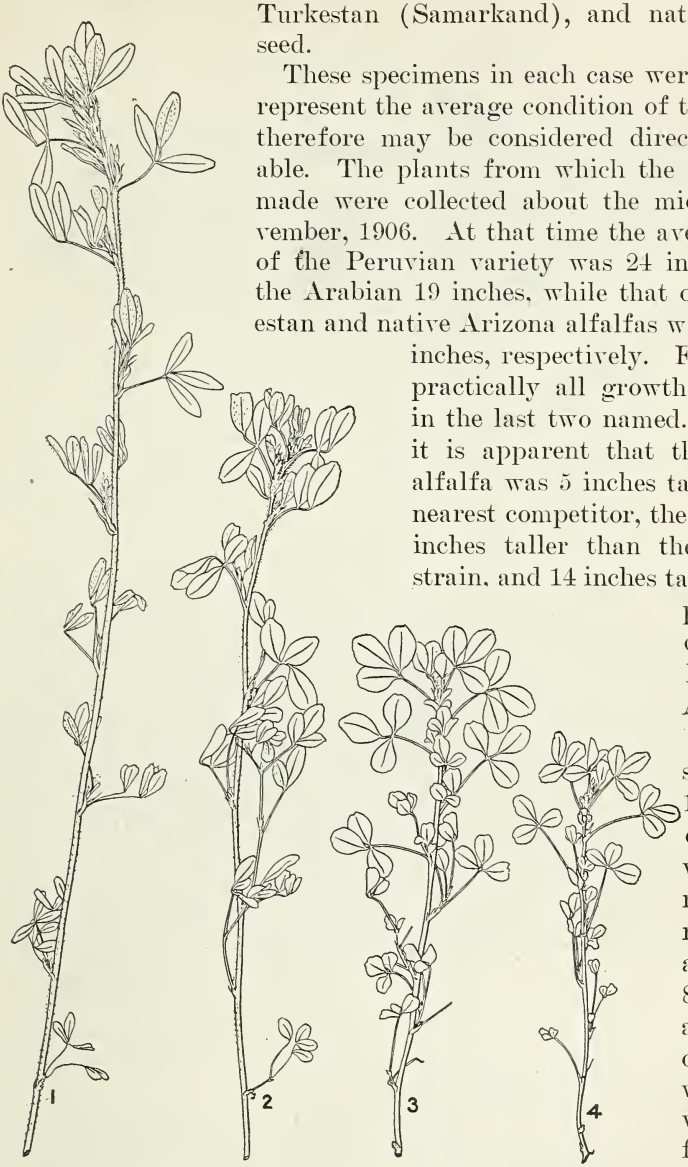

FIG. 3.—Comparative growth of various alfalfas: 1, Peruvian; 2, Arabian; 3, Turkestan; 4, Arizona. (One-fourth natural size.)

In the spring of 1907 these differences were even more marked, and on June 8 the average height of the Peruvian alfalfa was fully 3 feet, while none of the other strains averaged more than 2 feet. This difference is shown in Plate II, figures 1 and 2. The latter figure shows the well-known Oasis alfalfa (S. P. I.

No. 12846) of northern Africa, secured in Tunis by Mr. Thomas H. Kearney. The Arabian strain did not compare as favorably as in November, 1906.

COMPARISON OF ARABIAN WITH PERUVIAN ALFALFA.

Next to the Peruvian variety Arabian alfalfa has been found to have the lowest zero point. This interesting alfalfa was secured from Bassorah, Arabia, by Mr. David Fairchild, Agricultural Explorer. Several importations have been made from Arabia by Mr. Fairchild, and his notes concerning these, published in the inventories of the Office of Seed and Plant Introduction, deserve to be quoted in full:

8806. *Medicago sativa.* Alfalfa.

From Bassorah, Arabia. Received through Messrs. Lathrop and Fairchild (No. 904, March 15, 1902), June 7, 1902.

Djet. "This is treated like any alfalfa. (See No. 8823.) This is given a separate number as it comes from 500 miles south of the locality whence No. 8823 was sent. Secured through the assistance of Mr. Raphael Sayegh, of Bassorah." (*Fairchild.*)[a]

8823. *Medicago sativa.* Alfalfa.

From Bagdad, Arabia. Sent by Agha Mohammed, the Nawab at Kasimain and consular agent at that place for His British Majesty. Received through Messrs. Lathrop and Fairchild (No. 881, March 10, 1902), June 7, 1902.

Djet or *El-djet.* "A larger quantity of seed can be secured through arrangement with the American vice-consul at Bagdad, Mr. Rudulph Hürner. Although the Nawab admits this to be the best plant for horses he has ever grown, he says that he is the first in the region of Bagdad to grow it, and this, notwithstanding the fact that at Kerbella, only a day's journey away, large areas have been planted to it from ancient times. In the especially hot summers the fields are irrigated three times a month; in the cooler summers only twice. From 9 to 10 cuttings are taken each year, and the fields are manured with stable manure after each cutting. The life, i. e., profitable life, of a field of this *djet* is seven years. This variety should be admirably suited to our irrigated lands in California and Arizona, and deserves a trial in comparison with the Turkestan alfalfa. It should also be tested as to alkali resistance." (*Fairchild.*)[b]

12992. *Medicago sativa.* Alfalfa.

From Bassorah, Arabia. Secured through H. P. Chalk, esq., American consular agent. Received February 27, 1905.

"From preliminary tests of this alfalfa, made from a previous importation, under S. P. I. No. 8806, it seems probable that this particular strain will make a more rapid growth than the ordinary varieties cultivated in this country and

[a] Seeds and Plants Imported During the Period from September, 1900, to December, 1903. Inventory No. 10. Bulletin No. 66, Bureau of Plant Industry, 1905, p. 227.

[b] Loc. cit., p. 229.

may prove especially valuable for certain regions in southern California and Arizona. These preliminary experiments have been carried on at the Pomona substation in California, where this variety, together with the ordinary and the Turkestan varieties, planted side by side at the same time, exhibited most unusual rapidity of growth." (*Fairchild.*)[a]

The writer has not seen plants of No. 8823, but in June of the present season (1907) saw on the California substation farm at Tulare a plat of the original importation (S. P. I. No. 8806) mentioned by Mr. Fairchild. This has the same characters as the more recently imported seed (S. P. I. No. 12992) used in the present experiments.

The comparative amount of growth made at Yuma by the (1) Peruvian, (2) Arabian, (3) Turkestan, and (4) home-grown Arizona alfalfa from the date of last cutting up to November 15, 1906, is shown in figure 3. At that time the Arabian stood next to the Peruvian variety. During the present season, the Arabian alfalfa, though still easily second, has fallen off considerably in growth. In rapidity of growth, also, the Arabian sort is intermediate between Peruvian and ordinary alfalfa.

The zero point of Arabian alfalfa is higher than that of the Peruvian and lower than that of common alfalfa; hence, it has a shorter growing season than the Peruvian and a longer growing season than common alfalfa. It has the same lack of hardiness as the Peruvian variety, and its plants are also quite hairy. Nevertheless, the two varieties are readily distinguished from one another. The most evident botanical difference between the two is to be found in the leaves. The leaflets of the Peruvian alfalfa are very long compared to their width, being from 3 to 5 times as long as broad. The forms having three and four leaflets, shown in figure 8, are typical of the Peruvian variety. The leaflets of the Arabian alfalfa are, on the other hand, very broad in comparison to their length, giving an impression of roundness. They range from 1¼ to 3 times as long as broad. The average width was found by measurement to be 13.6 mm. and the average length 27 mm.

In its floral characters the Arabian is much nearer the common form (fig. 4) than is the Peruvian alfalfa (fig. 5). The flowers are usually smaller; the long calyx teeth characteristic of the Peruvian form are not present, nor are the teeth as long in comparison with the calyx tube in the Arabian variety.

The low zero point of the Arabian strain may have been brought about by long-continued cultivation under a mild winter climate per-

[a] Seeds and Plants Imported During the Period from December, 1903, to December, 1905. Inventory No. 11. Bulletin 97, Bureau of Plant Industry, 1907, p. 121.

mitting growth by plants having a low zero point. Like the Peruvian, the Arabian alfalfa has a high optimum temperature, acquired no doubt by cultivation since almost prehistoric times in hot deserts.

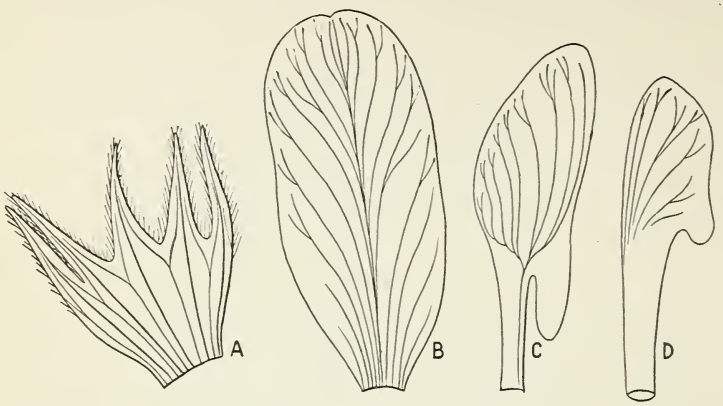

FIG. 4.—Floral parts of common alfalfa: A, calyx; B, standard; C, wing; D, keel. (Enlarged seven times.)

RECENT BOTANICAL HISTORY OF CULTIVATED ALFALFA.

The view that cultivated alfalfa is not one homogeneous species, but is composed of numerous strains, varieties, or even subspecies, requiring different cultural treatment, is a somewhat new one, but appears, nevertheless, to be correct.

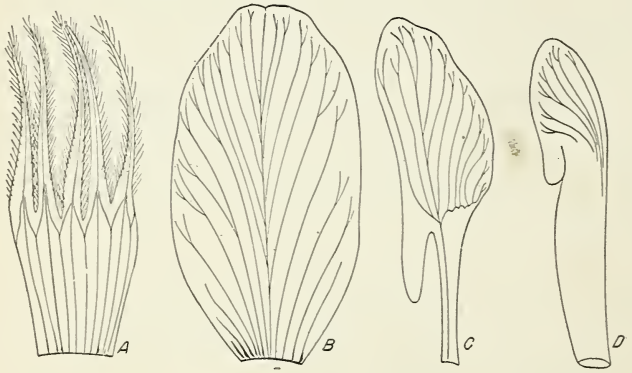

FIG. 5.—Floral parts of Peruvian alfalfa: A, calyx; B, standard; C, wing; D, keel. (Enlarged seven times.)

Alefeld,[a] in 1867, writing in Germany where alfalfa, or luzerne as it is there called, has been grown increasingly since 1573, having been introduced about that time from Spain through France, called atten-

[a]Alefeld, F. Ueber die Formen mehrerer Kulturpflanzen. Bot. Zeit., 25, 1867, p. 289.

tion to the now well-known fact that all cultivated plants vary extraordinarily on account of their being distributed by man into regions having far more diverse conditions than those to which they are subjected through the ordinary agencies of nature. However, he goes on to state that there is a very noteworthy exception to this well-nigh universal rule, namely, *Medicago sativa*, which was known to him in a large number of wild forms, but, despite its culture since remote antiquity, in only a single cultivated form.

In an earlier work Alefeld,[a] after a critical study of the wild forms alluded to above, most of which were collected in the Himalaya Mountains, described a number of new subspecies or varieties based on this material. All of these forms were placed in contradistinction to the cultivated one which he called *Medicago sativa vulgaris* ("gemeine gebaute Lucerne"), and regarded as one form with no varietal differences worthy of note.

Later, Urban[b] in his monograph of the genus Medicago recognized as valid Alefeld's classification of cultivated alfalfa in the subspecies *vulgaris*, and added one variety, *gaetula*, whose distribution is given as "only near Biskra, Algeria." Exact botanical knowledge of the forms of the cultivated plant has remained in practically this state until the present day. A few indefinite and imperfectly understood forms whose names are based largely on their geographical origin have in more recent times received a certain amount of acceptance.

By far the most widely known of these is the Turkestan alfalfa, sometimes loosely called the variety *turkestanica*, which has been imported in large quantities and has in some cases shown itself to be especially suited to particular sections of this country. As numerous distinct strains are comprised under this name, the variety has no botanical standing. Another form, specimens and seeds of which were sent from Tibet to Europe, has been called *tibetana* by Alefeld, *chinensis* by Werner, and by still other authors has been assigned to Alefeld's variety *rotundifolia*, to which Alefeld did not consider that it properly belonged. The foregoing represents approximately the present state of our botanical knowledge of cultivated alfalfa.

WILD FORMS OF MEDICAGO SATIVA.

Perhaps the most notable wild subspecies or varieties of *Medicago sativa* that have been described are *gaetula* and *tunetana*. These differ markedly from the variety discussed in this paper and all other cultivated forms in having glandular hairy pods and calyces.

[a] Alefeld, F. Landwirthschaftliche Flora, Berlin, 1866, pp. 74–76.

[b] Urban, I. Prodromus einer Monographie der Gattung Medicago L. Verh. d. bot. Vereins d. Prov. Brandenburg, 15, pp. 1–85, 1873.

Gaetula, although Urban's original description [a] of it is very inadequate, seems to have purple flowers, while the *tunetana* of Murbeck [b] has yellow ones. Both are native to the plateaus and mountains of northern Africa.

The little-known *Medicago pauciflora* Ledeb. and *M. coerulea* Less. are placed by Urban with his still more imperfectly described *piluliferа* as varieties of his subspecies *microcarpa*, characterized as having very small flowers, 6–6½ mm. in length, and pods with only one-half to 2½ turns and only 3 to 3½ mm. in diameter. No fully open flower or ripe pods of ordinary alfalfa or the varieties *tunetana*, *gaetula*, or Peruvian alfalfa are ever so small, and they are usually from 1½ to 2 times the dimensions given. Indeed, such small flowers and pods can only be found in the most immature specimens. *Medicago falcata*, with Koch's variety *glandulosa* and *M. media*, have no similarity to Peruvian alfalfa or other forms of the true *M. sativa* L.

DIFFERENCES WHICH DISTINGUISH PERUVIAN ALFALFA.

Accompanying and possibly correlated with the physiological differences which have been discussed are certain other characters in the form and habit of the plants which serve to distinguish this variety from the common one, both in the field and in herbarium specimens.

In the field Peruvian alfalfa is so obviously different from the alfalfa ordinarily grown that it is readily possible to tell at a glance where the plats of Peruvian alfalfa end and those sown to common alfalfa begin. This is true even in cases where no alleyways intervene between plats and during the summer when the plants are in the same stage of development.

The Peruvian plants are, on the whole, taller, the stems less branched, and fewer stems arise from each crown. (Pl. I.) The plants are also large and if left too long uncut become very coarse and woody. They are vigorous, erect in habit, of rapid growth, and make especially rapid recovery after cutting.

Perhaps the one character by which this variety can be most readily distinguished is the pubescence which covers the whole plant, somewhat sparsely at the base, but becoming increasingly dense in ascending until at the top the plants are densely covered with minute downy hairs. The common variety is, on the other hand, quite smooth except for a very slight hairiness at the top. A field or plat of the latter has the typical vivid green, while a plat of the Peruvian variety

[a] Loc. cit.

[b] Murbeck, Sv. Contrib. flore de la Tunisie, etc., in Lunds Univ. Arsskrift, vol. 23, 1897, p. 62.

has a silvery grayish green. This gray color of the Peruvian alfalfa is due not only to the hairiness of the plants but also in part to the fact that the veins of the leaves are almost white.

The midrib and secondary veins of Peruvian alfalfa are broader than those of ordinary alfalfa. This is due to the presence of a wider strand of colorless water-storage tissue which makes the leaves appear a paler green than those of the common alfalfa. This tissue is also present in the leaves of ordinary alfalfa, but because of the narrowness of the veins does not noticeably change the appearance of the plants.

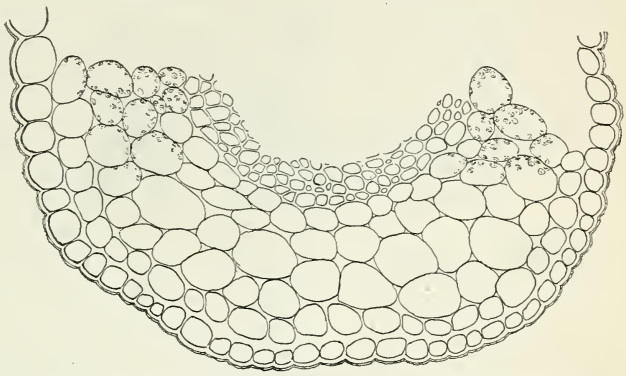

FIG. 6.—Cross section of midrib of terminal leaflet of Peruvian alfalfa, showing broad band of colorless water-storage tissue. (Magnified 240 times.)

Figures 6 and 7 show cross sections through the midrib of Peruvian and of ordinary alfalfa, respectively. These are magnified 240 times and show the dorsal epidermis and the water-storage tissue on the leptome side of the veins of the terminal leaflets.

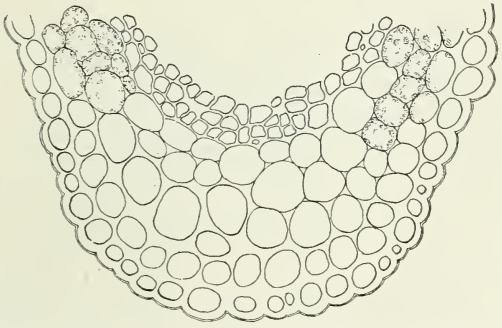

FIG. 7.—Cross section of midrib of terminal leaflet of ordinary alfalfa, showing narrow band of colorless water-storage tissue. (Magnified 240 times.)

The leaflets are rather long obovate, with wedge-shaped bases, and in primary leaves are practically all as long or longer than the leaf-stalks. The outer portion of the leaflets is toothed, the bases entire, and each midrib ends in a pronounced tooth. As compared with typical specimens of *Medicago sativa* the stalk of the middle leaf (petiolule) is very long in proportion to the main stalk of the whole leaf (petiole). More than fifty specimens of both forms were measured. In ordinary alfalfa the average length of the petiolule was found to be less than one-eighth the length of the petiole, while in the Peruvian variety it was more than one-fourth the length.

Many plants of the new variety have leaves with four, five, and even six leaflets, instead of the three characteristic of alfalfa. (See fig. 8.) Of nine specimens selected wholly at random from a field at Yuma four were found to bear some leaves having more than three leaflets. It seems probable that this character may bear some relation to the long petiolules referred to. The presence of numerous individuals showing this tendency furnishes an opportunity for improving the quality of alfalfa hay by increasing the proportion of leaves to stem material. It is believed that by careful selection a five or even a seven leafed type can be fixed, and selections are being made with this purpose in view. Should this result be obtained, another advantage will follow: While to a careful observer the plants of Peruvian alfalfa are obviously different from all others, the seed and young plants differ little, if at all. The additional leaflets would furnish an unmistakable mark of recognition that would tend to prevent the sale of adulterated seed to farmers at the high prices usually commanded by seed of a valuable new variety of a staple crop plant.

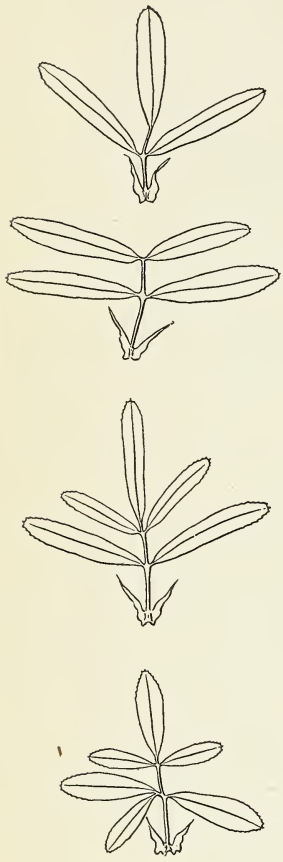

FIG. 8.—Three, four, five, and six leafed forms of Peruvian alfalfa. (One-half natural size.)

The flowers are generally longer than in ordinary alfalfa, some attaining a length of almost half an inch (12 mm.). Their characteristic color is plum purple, while in the common alfalfa it is violet. The calyx teeth are as long or longer than the calyx tube, longer than the pedicels—sometimes equaling in length the keel. (See figs. 9 and 10.) The floral bract which subtends the flower is longer than the calyx tube or the calyx teeth and up to twice as long as the pedicels, which are shorter than the calyx tube.

The pods are sparsely covered with rather long, simple hairs. Many of these characters fluctuate more or less, but the conditions described above are typical.

PERUVIAN ALFALFA CONSTITUTES A NEW BOTANICAL VARIETY OF MEDICAGO SATIVA.

In view of the numerous divergences which this strain presents, it is advisable that it be given a distinct varietal name. On the field the most easily recognized difference is the gray color of the plants previously mentioned, and this is best described by the term canescent. However, the Latin equivalent, *canescens*, has already been used for a variety of *M. orbicularis;* hence, the nearest Greek equivalent has been selected, and it is proposed to call the Peruvian alfalfa var. *polia.*[a] The type specimen, a portion of which is shown on Plate III, under No. 590159, and additional type material under Nos. 590160, 590161, 590162, and 590163, have been deposited in the National Herbarium. The following description is submitted:

FIG. 9.—Flower of common alfalfa, showing calyx teeth as short as calyx tube. (Enlarged six times.)

Medicago sativa L. var. **polia**, n. var.

Plants large, vigorous, pubescent throughout; stems erect with few branches, woody at the base. Leaflets of lower part of plant small, linear lanceolate; the upper leaflets large, rather long obovate, with cuneate bases; 3–4 times as long as broad; generally longer than petioles. Veins of the leaves white. Epidermal cell walls of the upper leaf face locally thickened. (See fig. 12.) Petiolules long in comparison to petioles, usually about one-third to one-fifth the length of the latter. Stipules large, ovate-lanceolate, generally without teeth on the inner margin, at the top of the plant often as long or longer than the petioles. Racemes 6–18 flowered, rather short, loose and not capitate. Flowers rather large, attaining a length of 12 mm. Pedicels from half the length to as long as the tube of calyx. Calyx thickly covered with appressed, not glandular, hairs; the teeth as long as the tube and up to 1½ times longer. Corolla plum purple, standard rather broad. Wings somewhat exceeding the keel in length. Legumes from 4 to 6 mm. in diameter; twisted spirally from 2 to 4 times; the spirals not compressed; covered with long hairs; the dorsal and ventral sutures thickened and prominent, the central aperture small but clearly defined.

FIG. 10.—Flower of Peruvian alfalfa, showing calyx teeth longer than calyx tube. (Enlarged six times.)

The spirals of most alfalfas are almost flat, while those of the Peruvian variety are not compressed and in fresh specimens have an

[a] Πολιός, with gray or white hairs, hoary.

inflated appearance. The small mature head in figure 11 shows this character. Few heads were mature; hence, the early one shown here is much smaller than the average.

FIG. 11.—Small mature head of Peruvian alfalfa, showing expanded spiral pods. (Enlarged 1½ times.)

The presence of local thickenings of the cell walls of the epidermis of the upper face of the leaves was detected by Dr. Theo. Holm. These thickenings, magnified 240 times, are shown in figure 12. They have been found to be present in some specimens of ordinary alfalfa, but are very sparse. Their presence has considerable value as a diagnostic character, although they can be seen only by using the microscope.

PERUVIAN ALFALFA SEEDS ABUNDANTLY.

Ability to set seed freely is of the greatest importance in bringing a new variety into successful culture. This is especially true in the case of alfalfas, clovers, and other leguminous forage plants. Peruvian alfalfa has this good quality in a marked degree. In many localities alfalfa blooms profusely, but the flowers blast and fall off without forming seed. Several causes are responsible for this, but the most important ones are insect injury and the prevalence of unsuitable weather during that part of the flowering period when pollination takes place most readily. Under the climatic conditions to which the Peruvian variety has shown itself best adapted the flowers are easily fertilized and produce an abundance of seed. Observations thus far recorded tend to show that this form seeds more freely in cool weather than in hot. This indicates that the optimum temperature for seed

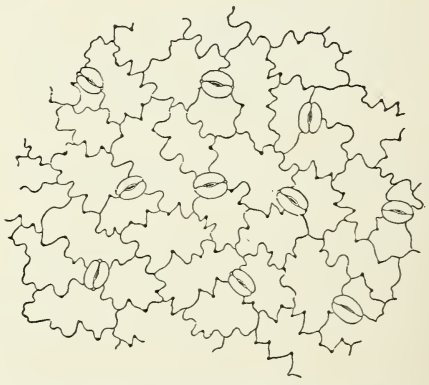

FIG. 12.—Local thickenings of the walls of the epidermal cells of Peruvian alfalfa leaves. (Magnified 240 times.)

production is considerably lower than the optimum for growth and that in both cases temperature is the limiting life history factor[a] controlling the functions in question.

The low optimum temperature for seed production may at first sight appear to work against the success of this alfalfa in the hot climate of the Southwest. This, however, is not proving to be the case, as the low zero point of growth makes possible the formation of seed in autumn when the temperature curves (see fig. 2) are falling. While definite data are as yet lacking on this point, it appears that an important practical advantage may result from the low optimum, as a later crop can then be devoted to seed production. This would result in an extra hay crop in years when seed is grown. Furthermore, farm work and other considerations make autumn the most convenient time for harvesting.

SOURCE OF PERUVIAN SEED.

The exact source in Peru of the seed used in these experiments (S. P. I. No. 9303) is not known. It was sent to the Department of Agriculture by Mr. Adolfo Eastman y Cox, who in his letter transmitting the same said:

> The seed sent is of the Peruvian variety, and I hope it is a true sample, as I asked the agents to spare no pains in getting seed of the best quality. I send it as a present to the Department of Agriculture, to whose liberality in sending me various of its publications I am deeply indebted.
>
> In the Experiment Station Record, trials on the value of different varieties of alfalfa are mentioned, but nowhere is the Peruvian variety spoken of. As far as my experience goes, the last has over the Chilean variety the following advantages: The stems are hollow and more succulent and grow higher. It commences its growth earlier in spring and grows till later in autumn. Owing to this advantage the crop per acre is heavier. On the other hand, care has to be taken in feeding cattle on it, as it is apt to produce hoven (bloating).
>
> I should be pleased if the results obtained with it would correspond with my desire that it may be of some use to American agriculturists.

It is probable that the tendency to cause bloating mentioned by Mr. Cox may be due to the hairiness of the plants, as is the case in red clover. It has been found that in thick stands the plants have very few hairs except at the top. Thick seeding, not less than 20 to 25 pounds to the acre of good germinable seed, is therefore recommended. In addition, this overcomes the tendency of the plants to

[a] The theory of limiting factors has been recently discussed by several investigators. Perhaps the most notable papers that have appeared are those of Blackman and Smith, as follows: Blackman, F. F.: Optima and Limiting Factors, in Ann. Bot., 19: 281–295, April, 1905. Smith, A. M.: On the Application of the Theory of Limiting Factors to Measurements and Observations of Growth in Ceylon, in Ann. Roy. Bot. Gardens, Paradeniya, 3: 303–375, November, 1906.

become hard and woody, leaving the stems even more succulent than those of the common alfalfa at the same stage of growth.

It is not known that the divergences which have been described as separating this variety from our commonly cultivated form hold good for all seed of Peruvian origin. Indeed, there is every reason to believe that they do not; but it does seem reasonable to suppose that the parent seed of the lot used in these experiments may have been grown for many generations at a high altitude in an equatorial region where the annual range of temperature is comparatively small—the summers are not very hot nor the winters very cold. There are well-authenticated reports of alfalfa growing in the Andes up to an altitude of 3,426 meters, or, roughly speaking, 11,000 feet. In this connection, a further illustration has been found of the practical importance of the zero point in plant economy.

ALFALFA PROPAGATED BY CUTTINGS.

André,[a] in a description of Ibarra (78° 17′ W.; 0° 24′ N.; alt. 7,530 feet) and its environs in northern Ecuador, thus describes a method of vegetative propagation [b] of alfalfa which he found in use in this region:

> In examining the methods of cultivation, I found that lucern—the alfalfa so valuable for stock—is not sown but planted by hand. In order to seed down a field it is first plowed deeply, and the soil well loosened—which is easy in these sandy soils—then pieces of the roots of lucern are planted 50 to 60 centimeters (20 to 24 inches) apart. A crop the same year is assured, whereas two years' delay results if seed is used. It is now June, the time when this planting is done. The farming population is also harvesting the peas, beans, and wheat.

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[a] André, Ed. L'Amérique équinoxiale, etc., in Tour du Monde, vol. 45, No. 1171, 1883, first half year, p. 374.

[b] Westgate and Oliver, in a recent bulletin (The Application of Vegetative Propagation to Leguminous Forage Plants, Bul. No. 102, Part IV, Bureau of Plant Industry, 1907), describe a method of propagating alfalfa from cuttings suggested by Dr. B. T. Galloway. Inability to secure sufficient quantities of seed has often delayed the bringing of newly introduced plants into commercial culture. Work in selection has also been greatly hindered by the length of time required for propagating seed enough for field trials. The method of propagation by cuttings described in the bulletin mentioned will be very useful in helping to overcome both of these difficulties. A few plants of the Peruvian alfalfa described in the present paper, which withstood the winter of 1903–4 in Washington, were used as the basis of their experiments. It was observed that in 1903 a plat of Peruvian alfalfa in the grass garden of the Department of Agriculture was not injured by the leaf-spot fungus (*Pseudopeziza medicaginis*), while a check plat of common alfalfa was almost destroyed. Although leaf-spot is not regarded as a particularly destructive disease in regions where alfalfa is grown under irrigation, it does considerable damage under the humid conditions prevailing in the eastern United States, where great interest is now taken in alfalfa culture.

André further states that he found the mean annual temperature, measured by the method of Boussingault, equal to 16° C. (60.8° F.).

It is apparent from this that the sum of the daily temperatures above the zero point during the growing season is sufficient to produce a crop during the same year if the method of propagation by cuttings is used, but when seed is used two years are required to reach a sufficient total sum of heat to produce a crop. In this case, however, the low zero point is a secondary factor, as the difference in the time required is not due wholly to ability to grow at relatively low temperatures. Another factor—the utilization of a reserve supply of plant food—is probably the most important influence in shortening the time necessary for producing a hay crop.

That the practice of propagation by cuttings is still used with great success in the Ecuadorian plateau is shown by a recent report on alfalfa culture by Consul-General Herman R. Dietrich, of Guayaquil, based on information furnished by Señor Luis Martinez, formerly chief of the section of agriculture of the Department of Public Instruction of Ecuador. The paragraphs in question are as follows:

Cultivation.—Sometimes the seed is sown broadcast in the field, but the most usual manner is to transplant the shoots in lines or furrows, to facilitate irrigation. After each crop is cut the soil at the roots of the plant is loosened and the field is irrigated.

Yield.—In rich soil the yield is enormous, sometimes reaching 120,000 pounds per hectare per year. The normal yield is 80,000 pounds. In the table-lands the alfalfa gives from five to seven crops yearly. In the very high altitudes, of 2,800 meters or more, it scarcely gives three crops per year.

As there is no winter in Ecuador the alfalfa is always fresh and vigorous, and for that reason it is not made into hay.

THE GUARANDA ALFALFA OF ECUADOR.

The famous "Guaranda" alfalfa, so called because extensively grown around Guaranda, the capital of the province of Bolivar, at an altitude of about 8,894 feet, proves to be very like the Peruvian alfalfa already described. The Guaranda alfalfa sent to the Department of Agriculture by Señor Martinez (S. P. I. 14972) shows the same upright habit of growth as the Peruvian alfalfa, the same or a very similar zero point for growth, and the same large plum-colored flowers and long calyx teeth. Although much more hairy than ordinary alfalfa, it is not so hairy as the Peruvian, and the petiolules are slightly shorter in proportion to the petiole. Aside from these two points last mentioned the Guaranda alfalfa seems to be the same as the Peruvian, and more complete material will probably prove it to belong to the variety *polia*, which doubtless extends to all the high table-lands along the Andes where alfalfa culture is practiced.

The well-known botanist Luis Sodiro, S. J., writes concerning alfalfa culture in the higher Andean plateau as follows:[a]

. . . The "Velasco" property, belonging to Señor J. Julio Barba, near the town of Pomasqui, three leagues from Quito, . . . is situated at an elevation of 2,800 meters (9,186 feet); the mean temperature is between 15° and 16° C. (59°–60.8° F.), with slight variations between the day and the night; the soil is sandy and sufficiently provided with organic matter; the surface is almost horizontal; the irrigation, though not abundant in proportion to the extent of the tract cultivated, is amply sufficient for the needs of vegetation. . . .

I visited this property during the latter part of August of the present year, and in spite of the five months' drought that had just passed, interrupted only by a few light showers of rain, I found the whole field in the best state of growth that could be desired. The turf in flower, then near the time of the harvest, measured from 80 to 100 centimeters (31 to 39 inches) in spite of being only 50 days old.

Ordinarily cuttings are made every sixty days. Each square, consequently, may be cut as many as six times annually.

The variety that is cultivated there is what is called the "Guaranda," from the town of this name in the province of Bolivar.

The preparation of the land for planting depends on its condition and requires its division into sections, the making of the proper canals for irrigation, cleaning it from weeds, etc. In sowing the seed it is usual to employ from 20 to 25 pounds per hectare (17¾–22¼ pounds per acre). Four or five months after the sowing it is in condition to be cut for the first time,[b] after which it does not require more than from fifty to sixty days, according to the local conditions, between one cutting and another, to be newly harvested.

The value of the annual product of a hectare can be considered as from $12.50 to $15, and the cost of production from $3 to $4. A field well cared for will remain in good condition for thirty years; but these figures will also vary greatly according to the condition of the soil, so that it is difficult to formulate general data.

At Phoenix, Ariz., Guaranda alfalfa sown with eleven other sorts early in November, 1906, was reported on February 23, 1907, as having an "excellent stand" and being the "best looking alfalfa on the plats," despite the late date of seeding.

ADVANTAGES AND DISADVANTAGES OF PERUVIAN ALFALFA.

It is just as important to know the weaknesses of a variety as its points of strength.

The present investigations have demonstrated that in the area to which it is suited Peruvian alfalfa has numerous advantages over all other sorts. It has greater vigor, grows more rapidly, and recovers

[a] This important letter, dated Quito, September 28, 1907, is addressed to Consul-General Herman R. Dietrich, at Guayaquil, whose kindness in sending this and other valuable information on Andean alfalfa culture is here gratefully acknowledged.

[b] To judge from André's statements (p. 26), it is highly probable that such alfalfa fields must have been planted with cuttings, as seedling alfalfa could scarcely reach a sufficient height for cutting in four or five months if grown at an altitude of 9,000 feet or thereabouts.

more quickly after cutting. By reason of its low zero point of growth it has a longer growing season, under favorable conditions continuing growth throughout the winter. It is more resistant to frost and matures its seed later in the autumn. These factors result in the production of one or two additional hay crops each year.

When grown in the region to which it is suited but two disadvantages have been noted—hairiness and a tendency to become woody. It has been found that both of these adverse conditions can largely be prevented by thick seeding. Lack of hardiness will always confine the Peruvian variety to limited areas. On account of the tendency of the stems to become hard and woody, it is not suitable for cultivation in regions where dry farming is practiced, for in order to secure the best results in the dry-land culture of alfalfa thin seeding is a necessity.

SUMMARY.

In the course of life history studies of alfalfa it has been found that a Peruvian strain, seed of which was presented to the Department of Agriculture by Mr. Adolfo Eastman y Cox, of Chile, is sufficiently different from all other alfalfas to constitute a distinct botanical variety. In addition to many technical differences, this new variety grows more rapidly, makes quicker recovery after cutting, begins growth earlier in spring, and continues growth later in autumn than the strains commonly cultivated. This results in one or two additional cuttings each year, thereby greatly increasing the yield to the acre. Besides this, the yield for each cutting is greater on account of the vigorous growth of the plants.

These differences, so important from an economic standpoint, have been explained in large part through the determination of the zero point of growth of this variety. The zero point of any crop plant may be briefly defined as the mean temperature above which growth begins in spring and below which it ceases in autumn. Peruvian alfalfa has an unusually low zero point, which enables it to take advantage of temperatures too low to stimulate growth in other kinds.

The view that cultivated alfalfa (*Medicago sativa* L.) is not one homogeneous species, but is composed of numerous strains, varieties, or even subspecies, appears to be substantiated by the present investigations.

The name *Medicago sativa* var. *polia* is proposed for the new variety, of which a technical description is given, together with a discussion of the probable conditions under which it originated.

Investigation has shown that Peruvian alfalfa can be grown to greatest advantage only under irrigation and in the Southwest, where the climate is mild in winter. It winterkills easily and hence should

not be grown where the winters are rigorous. It is not known to be drought resistant, and even if it should prove to be it has the drawback of becoming very woody if sown thinly, as is necessary when dry-land alfalfa culture is practiced. The chief causes of success in the area to which this alfalfa is suited and the main reason for failure in the region to which it is unsuited have been found to depend on the same factor, namely, the low zero point of growth. In the one case this makes growth possible during an unusually long season, resulting in greatly increased yields; while in the other it is responsible for the presence of tender tissue when cold weather comes, which results in the killing of the plants by the first severe freeze.

It is hoped that the observations here recorded will indicate lines on which the breeding and selection of alfalfa and other crops may be conducted, based on a knowledge of the life-history factors controlling the growth of the plant.

The Department of Agriculture has very little seed of this variety on hand at the present time, and none for general distribution. During the current season it is hoped that a small supply for propagating purposes will be secured from the experiments now under way. Cooperators who have been furnished with seed should devote their plats to seed production, in order to aid in the extension of this promising alfalfa in the area to which it is particularly suited—the Southwest.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. (*Frontispiece.*) A single plant of Peruvian alfalfa, showing its habit of growth, lack of branching, etc. It is 3 feet from the ground to the arrow near the top. The plant is one year old and was grown at Yuma, Ariz. Two stems from the plant here shown have been deposited in the National Herbarium under No. 590160 as paratypes. (Negative by Mr. C. S. Scofield.)

PLATE II. Fig. 1.—A plat of Peruvian alfalfa on the United States Reclamation Service tract, Yuma, Ariz. Average height of plants fully 3 feet. Photographed June 6, 1907. Fig. 2.—Kebilli Oasis alfalfa growing on a plat contiguous to that of the Peruvian variety shown in figure 1. Although these plats are of the same age and have received the same cultural treatment, the Oasis alfalfa is not yet knee high, while the Peruvian is nearly waist high. Photographed June 6, 1907.

PLATE III. A specimen of Peruvian alfalfa, photographed June 6, 1907, at natural size, from fresh material grown at Yuma, Ariz., showing flowers and almost mature head. This branch and the stem from which it was taken have been deposited in the National Herbarium under No. 590159 and constitute the type of *Medicago sativa* var. *polia*.

FIG. 1.—A PLAT OF PERUVIAN ALFALFA ON THE UNITED STATES RECLAMATION SERVICE TRACT, YUMA, ARIZ.

FIG. 2.—A PLAT OF KEBILLI OASIS ALFALFA GROWING ON A PLAT CONTIGUOUS TO THAT OF THE PERUVIAN VARIETY SHOWN IN FIGURE 1.

A SPECIMEN OF PERUVIAN ALFALFA, SHOWING FLOWERS AND ALMOST MATURE HEAD.

(Natural size.)

INDEX.

	Page.
Africa, northern, alfalfa varieties	20
Alefeld, botanical history of alfalfa, notes	18, 19
Alfalfa, Arabian, advantages in ostrich farming	9
average height	15
comparison with Peruvian alfalfa	16–18
description and note on zero point	17
growth, compared with Peruvian	17
high optimum temperature, how acquired	18
Arizona, growth, compared with Peruvian alfalfa	15
cultivated, recent botanical history	18–19
flowers, comparison of Peruvian and common variety	23
Grimm, from Minnesota, hardiness	8
growth, comparison of Peruvian with other varieties	14–16
Guaranda, description and similarity to Peruvian alfalfa	27–28
growth at Phoenix, Ariz	28
where produced	28
hardiness dependent on zero point of growth	8–14
introduction into Germany, date	18
South America, probable origin	13
life history study	7
Montana, hardiness, seed from Milk River valley	8
not one homogeneous species	18
Oasis, growth, compared with Peruvian alfalfa	15
source	16
ordinary, retardation of growth, negative temperatures	12
temperatures utilized	10–12
zero point, estimated	10
of growth hard to locate on account of frost injury	10
Peruvian, advantages and disadvantages	9, 28–29
in ostrich farming	9
characteristics	20–22
comparison with Arabian alfalfa	16
constitutes a new botanical variety	23–24
frost endurance	8
growth, comparison with several other alfalfas	14–16
high optimum temperature of growth, how acquired	12, 13
immunity from leaf-spot fungus	26
lack of hardiness in northern localities	8
low optimum temperature for seed production	25
zero point of growth, effect, importance, how acquired, etc	8–14
regions to which adapted	8, 9
seed, abundant production	24–25
source	25–26

Page.
Alfalfa, Peruvian, temperatures utilized 10–12
unsuitable for dry farming 29
winter growth, Colorado River valley 8
under favorable conditions 9
pasturage for cattle, etc 9
winterkillled, percentage of plants 8
woodiness of stems, how overcome 29
zero point, approximate location 9–12
propagation by cuttings 26–27
Turkestan, classification 19
growth, compared with Peruvian alfalfa 15
height, comparison with other varieties 15
varieties and wild forms 18–21
effect of temperatures at Yuma, Ariz 10–12
Andean plateau, alfalfa cultivation and yield 28
André, Ed., on propagation of alfalfa by cuttings, note 26
Arabian alfalfa. *See* Alfalfa, Arabian.
Arizona alfalfa. *See* Alfalfa, Arizona.
Yuma, mean temperatures for 1906, effect on alfalfa 10–12
Blackman, F. F., on limiting factors, note 25
Bloating, cattle, caused by Peruvian alfalfa 25
Breeding alfalfa, possibility of increasing number of leaflets 22
Cattle bloating, caused by Peruvian alfalfa 25
Climate, North and South America, comparison of temperatures 14
Colorado River valley, winter growth of Peruvian alfalfa 8
Cuttings, alfalfa propagation 27
De Candolle, Alphonse, on difficulty of locating zero point of growth 12
Dietrich, Herman R., on propagation of alfalfa by cuttings, Ecuador, note 27
Djet. *See* Alfalfa, Arabian.
Ecuador, alfalfa cultivation and yield 27
Quito, mean annual temperature 13
Fairchild, David, on alfalfa importations from Arabia, notes 16
Gaetula, variety of alfalfa 19
Frost endurance of alfalfa, relation to growing of crop 8–14
Guaranda alfalfa. *See* Alfalfa, Guaranda.
Hairiness, Peruvian alfalfa, objections and prevention 25, 29
Heat requirements of plants 12
Hoven. *See* Bloating.
Introduction to bulletin 7
Leaf-spot fungus of alfalfa, note 26
Life history study of alfalfa 7
Lima, Peru, mean annual temperature 13
Luzerne, German name for alfalfa 18
Medicago sativa gaetula 19, 20
importations from Arabia 16
polia 23
tunetana 19, 20
varieties and wild forms 18–21
vulgaris 19
wild forms 19, 20
Oasis alfalfa. *See* Alfalfa, Oasis.
Oliver and Westgate, method of propagating alfalfa by cuttings, note 26
Ostrich farming, advantages of alfalfa with low zero point 9

Page.
Peru, Lima, mean annual temperature 13
Peruvian alfalfa. *See* Alfalfa, Peruvian.
Plants, heat requirements 12
Plates, description 32
Polia, variety name for Peruvian alfalfa 23
Propagation, alfalfa, use of cuttings 26
Provence alfalfa, cessation of growth in autumn 8
Pseudopeziza medicaginis, injury to alfalfa, note 26
Quito, Ecuador, mean annual temperature 13
San Diego, Cal., mean annual temperature 14
Seed, Peruvian alfalfa, abundant production 24–25
source 25–26
Seeding, thick, for prevention of hairiness in Peruvian alfalfa 25
Smith, A. M., on limiting factors, note 25
Sodiro, Luis, on alfalfa culture in Andean plateau 28
Summary of bulletin 29–30
Swingle, Walter T., on heat requirements of the date palm, note 12
Temperature, high optimum of growth, Peruvian alfalfa, how acquired 12, 13
Temperature, negative, effect 12
positive and negative, defined 12
Tunetana, variety of alfalfa 19, 20
Turkestan alfalfa. *See* Alfalfa, Turkestan.
Turkestanica, variety of alfalfa 19
Urban, I., on classification of alfalfa, notes 19
Varieties and wild forms of alfalfa 18–21
Weather, relation to growth of alfalfa 8–14
Westgate and Oliver, on propagation of alfalfa by cuttings, note 26
Yuma, Ariz., mean temperatures for 1906, effect on alfalfas 10–12
Zero point of growth, approximate, Peruvian alfalfa 9–12
definition, note 8
difficulty of determining 12–14
estimated, ordinary alfalfa 10
explaining hardiness of alfalfa 8–14
high, cause of early dormancy of plants 9
low, significance under favorable conditions 9
unfavorable conditions 9

O

[Continued from page 2 of cover.]

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